PRIVATE AND CONFIDENTIAL

ENGINEERING DIVISION

Visit to United States

30th November–9th December 1962

REPORT No. A·076

1963/3

THE BRITISH BROADCASTING CORPORATION

ENGINEERING DIVISION

VISIT TO UNITED STATES

30TH NOVEMBER - 9TH DECEMBER 1962

Report No. A-076

(1963/3)

H. Page (Research Department)

(H. Page)

D.E. Todd (Planning & Installation Department)

(D.E. Todd)

Report No. A-076

VISIT TO UNITED STATES

30TH NOVEMBER - 9TH DECEMBER 1962

PRIVATE AND CONFIDENTIAL

January 1963

Report No. A-076
(1963/3)

VISIT TO UNITED STATES
30TH NOVEMBER - 9TH DECEMBER 1962

1. PURPOSE OF VISIT

The BBC were invited to send representatives to a Conference of the VOA Science Advisory Group which was held at Greenville, North Carolina, from December 3rd - 5th, 1962. As a result, the writers attended the Conference, as did also Mr. H.K. Robin of the Diplomatic Wireless Service. The Agenda[1] and other papers presented at the Conference are listed in Section 6, and are available to anyone interested.

The opportunity was taken to pay visits to the NBC video-tape section at the New York studio centre, the Federal Communications Commission at Washington, RCA Camden, and stations WNYC (New York) and WBAL (Baltimore). The discussions on these visits are sub-divided in Section 3 according to the subject matter discussed.

2. VOA CONFERENCE (December 3rd - 5th)

2.1. VOA Progress Report

Mr. Henry Loomis (Director, VOA) reviewed progress since the previous meeting. The Greenville h.f. installation is now virtually complete. It is divided into two transmitting and one receiving sites (see Section 2.2.); the first transmitting site was due to start regular scheduled transmissions on Friday, 8th December, and the second site on 8th February 1963. The 500 kW Continental Doherty transmitters were being run at 250 kW due to corona trouble on the arrays, but this would be overcome. There had also been some deterioration in Jennings vacuum capacitors during ten years of storage.

In Liberia, the first 50 kW m.f. transportable station was on the air, having been air-lifted from Texas in eleven C124 transports. Two more 50 kW transportables were on the way by sea, and would be on the air at the end of the year. The rest of the Liberia project was slightly behind schedule, but the land had been cleared and drained, and the concrete building was being made ready for power.

Woofferton is going according to schedule.

The Rhodes station is due on the air in March 1964 (one 150 kW m.f. and two 50 kW h.f.).

In Thailand, they were having site acquisition difficulties, and there was only a 50/50 chance of success for this 1 MW m.f. project.

Financial approval for $9·6M of a $25M project in Bambula (W. Pacific) is expected to be approved next May. This station may be in Myaco or in the Phillipines; they had not yet decided which.

A proposal for a station in Cyprus has been killed by the $1M land revenue demand, and the plant will probably be put in Greece instead (there are good hopes of agreement to this proposal).

No replacement has yet been found for Tangier, where the lease runs out in December 1963. A small site (of about 50 acres) has been found in Malta, but the ground is very difficult and uneven. This site would be valuable to cover central and eastern Europe, as well as providing a 'back-up' feed to Ceylon and England.

Programmes have been sent to Rhodes in teletype for reading locally, thus achieving good medium-wave quality.

Arrangements are being made for the initiation of a programming service based at Monrovia, for political rather than administrative reasons.

There was some discussion on receivers to be used for overseas monitoring; the Racal was thought to be very good (they are used at Greenville), but at $2000 too expensive for this duty. They were using the Collins 51J.

A total of $10M has been allocated for improvements to plant in the U.S.A. This will cover the provision of 250 kW transmitters at Dixon, Toledo and Bethany. An enquiry is out for nine 250 kW h.f. transmitters, and this includes a clause providing an option on a further ten, i.e. a total of 19 extra 250 kW transmitters for communication with the relay sites.

For 1963, $1M has been allocated for major maintenance and repair and $0·5M for research.

2.2. Greenville Installation

The Greenville installation consists of:

Sites A and B	Two separate transmitting sites, each of approximately 2200 acres, having identical facilities.
Site C	Receiving site of approximately 600 acres. This is also the administrative centre.

2.2.1. Transmission Facilities

The complement of transmitters is:

3 × 500 kW (each of 2 × 250 kW) Doherty type
3 × 250 kW Class-C
3 × 50 kW
2 × 5 kW

These can be switched to any one of the 36 arrays through a single 11 × 36 switching station, of RCA design. The switches are similar in principle to those being provided at Daventry and Woofferton; P.I.D. have full details of them. The arrays comprise dual-band curtains and rhombics in about equal numbers, together with two log-periodic arrays; the latter have only a small gain (about 10 dB) and merely serve as a feed for the Bethany station.

Almost all the feeders are designed for 500 kW working. They are of the 4-wire type, the upper wire consisting of a ½ in diameter stranded conductor and the lower being a ½ in diameter tube. The four wires are spaced approximately 9 in × 2 in, giving a characteristic impedance of 300 ohms. Specially shaped clamping pieces are used at a support point, to offset the effect of the insulator capacity.

The three-wire rhombics are conventional, and have a s.w.r. not exceeding 1·5 over the octave band.

The curtains are of the dual-band HR4/4/1 type,* but use an aperiodic reflector, comprising horizontal wires about 2 ft 6 in apart; the back-to-front ratio is about 23 dB. The arrays are supported by four relatively slim masts, each pair supporting one curtain, rather than two masts with spreaders. The VOA arrangement (which is also used at Lopik) is claimed to be cheaper than that of the BBC, but is less flexible, since the spacing between curtains is fixed. The radiating elements (each of three coplanar wires spaced about 2 ft 6 in apart) are branch fed, with an impedance of 600 ohms at the drive point. Line transforming sections give an approximately matched impedance at each branch point, and to the downcoming 300 ohm line, without any other matching. Matching to the main line is then achieved by a series of stubs, spread over a length of main feeder of about 100 ft; this is permissible since no slewing facilities are provided.

To accommodate the three sets of vertical feeders, one is taken up on the 'blind' side of, and through a 'window' in, the reflector curtain; this would not be possible if the array had to be reversed. The aerial is broadly matched over the whole of the band between the two in use, rather than in each working band. The maximum s.w.r. is about 1·5, but is stated to be considerably less over most of the band.

The switch s.w.r. was specified to be 1·25. The overall s.w.r. was stated to be not worse than 1·2 to 1·3 generally speaking, possibly 1·5 in extreme cases; these figures must be regarded as tentative for the time being, as the measurements were still in progress at the time of our visit and it is doubtful whether all the combinations had been checked. If the estimates are not exceeded even in extreme cases, some degree of adventitious correction must be occurring.

* Photographs of the arrays are available.

We came to the conclusion that the arrays at Greenville were well-designed both mechanically and electrically, but that the system was less flexible than the BBC arrangement in the sense that:

(i) the arrays are omnidirectional; the untuned reflector eases the problem of matching over a band of frequencies

(ii) no slewing facilities are provided; this also eases the matching problem

(iii) the curtain spacing is fixed by the mast lay-out.

The flexibility of the VOA system was, however, increased by having arrays working on bands, say, A/B, B/C, C/D, D/E, etc., rather than for bands A/B, C/D, etc. This BBC arrangement is proposed in order to reduce the development work and the number of 'standard' arrays.

2.2.2. Receiving Facilities

The receiving site provides the normal programme feeds from Washington; twelve programme or teleprinter circuits are provided via a microwave link, and passed on to sites A and B in a similar manner. In addition, h.f. feeds from VOA stations abroad are available for 'reportage' services.

The site was required to be a minimum of 10 miles (it is actually 20 miles) from the transmitting sites. This spacing is based on experience at Liberia, where 5½ miles is considered too close. Whereas in Liberia reception is possible in the same band only if the frequency spacing is a few tens of kilocycles, at Greenville 20 kc/s separation is considered feasible, even when radiating in the direction of the receiving site; however, no actual proving tests to this effect have yet been carried out.

The twenty rhombic aerials are used in dual-diversity, the associated rhombics being spaced about 6λ; each is connected through a balanced open-wire line to a point just outside the building, and thence by co-axial cable. Each rhombic is connected to a Rohde & Schwarz multi-coupler, giving six outputs with a nominal gain of 0 dB, and thence to a Racal receiver; the Racal receivers were very favourably regarded. A single-sideband selector can also be associated with each receiver, if required.

There are also two log-periodic aerials, each of 17 elements.

2.3. Propagation

2.3.1. Backscatter Sounding

Stanford Research Laboratories (SRL) have developed a carrier frequency-shift method of back-scatter sounding, and have tested it at Munich.[2] The frequency shift was 7·5 kc/s for periods of 2 ms, with a p.r.f. of 6 per second. The method is claimed to be simple, to give greater immunity from jamming than previous methods, and to cause less interference to the listener.

Although SRL were trying to 'sell' this method of sounding, they were not able to make any new suggestions as to how back-scatter sounding could be used to give useful operational information, apart from MUF and skip-distance information over one-hop paths. The limitations published by one of us (contribution by H.Page to: Shearman, E.D.R., 'An Investigation of the Usefulness of Back-Scatter Soundings in the Operation of H.F. Broadcast Services', Proc.I.E.E., Part B, Vol.108, July 1962, p.373) were agreed by one of the SRL representatives concerned, in private discussion. Moreover, in their recommendation,[3] SRL stated that 'the best way to integrate this information into VOA operations has yet to be found'.

No direct operational use of back-scatter sounding is planned at present by VOA, but it may be used on new circuits (see Section 2.3.3.5) and SRL would be regarded as being 'on tap' for interpretation of the results.

2.3.2. Anti-jamming Measures

SRL have proposed a method[4] of overcoming jamming of VOA transmissions by 'spreading' one programme over a number of channels. The transmitter oscillator is phase-modulated at 15 - 30 kc/s so that one or more sidebands appear at these frequency spacings, on each side of the normal transmission. The total spread can, therefore, be of three to five channels, depending on the degree of phase modulation; the effective power available is correspondingly spread over a number of channels. In theory, the spectrum of course extends much further, although with rapidly decreasing amplitude. The technique was claimed to be useful to 'break through' jamming, but was regarded as only applicable for emergency purposes.

This seemed to us a highly dangerous proposal; it would not be difficult to jam, and would rapidly lead to conditions even more chaotic than those prevailing at present in the h.f. band. In private discussions, however, we learned that the VOA have no intention of using the technique. Nevertheless, we feel it sufficiently important for the BBC to take up this matter formally with VOA.

A further proposal from SRL was to use 'twilight immunity' to minimize jamming of a signal required for rebroadcasting purposes.[3] A receiving site is chosen to give a wanted-signal MUF higher than can be used from the jamming country, at least at certain times of the day. This is generally only practicable during twilight hours. In winter evenings, for instance, at Tangier a band of 1·5 Mc/s is immune from jamming from Russia, but for Canary Islands the corresponding figure is 11 Mc/s. In summer, the Tangier site has no immunity, whereas the Canary Islands site has a small degree of immunity in the evening. Political questions aside, Canary Islands or Madeira would be suitable for serving the East Mediterranean or Munich, but the VOA would like to retain Tangier, even at a high price.

The results of an eight-hour barrage broadcast to Russia on October 25th, carrying President Kennedy's Cuba statement, was regarded as highly successful, with some channels clearly received even in Moscow.[5] Generally speaking, the jamming remained solid on those channels which normally carry Russian and Ukranian. On previously unused channels, some were clear throughout and some were jammed only part of the time.

The general jamming picture is much the same as reported previously. All transmissions in Russian are regularly jammed, as also are those to the Eastern-bloc countries, excluding Poland and Albania.

2.3.3. Propagation Studies

Bureau of Standards have a large h.f. study programme of work related to VOA activities.[6] The main projects are:

2.3.3.1. Frequency Prediction and Ray Tracing

A computer has been programmed to give the diurnal variation of MUF, FOT (optimum traffic frequency), probable vertical angle, field strength, and expected signal-to-noise ratio. In this study, certain simplifications have been made. For instance, modes propagated at less than 5° have been neglected if a higher-angle mode is possible. Again, only the strongest mode has been calculated.

It is difficult to say, without detailed study, how these restrictions limit the usefulness of the method. A first glance suggests that there are some anomalies, and the technique in its present state was put forward by NBS in a somewhat cautious manner.

An example of the information available from the computer is given in Reference 7. This deals with a study of h.f. propagation conditions from Manila, Phillipines; it was stated that the use of the computer permits such a study to be made in about one week. The best way of incorporating E-layer propagation in the predictions is also under consideration by NBS.[6]

SRL are also working on the problem of how waves are propagated over a long path, by a study of the Okinawa-Greece circuit. Though less sophisticated than that of Kift (DSIR) SRL claim their method gives better agreement with measurements. On the other hand, Kift says that his method is more accurate over the Delhi-U.K. path which he is studying.

2.3.3.2. High-Frequency Circuit Transmission Loss

This project is associated with CCIR work. Further work has been done on the relative roles of the E- and D-region absorption, and the results are compared with Signal Corps Technical Note No.9, which is used by the BBC. It is also proposed to make comparisons with other methods.

2.3.3.3. Sunspot Cycle

This subject was covered only briefly. With the approaching sunspot minimum, the only techniques available are the use of the lower frequencies, and an increase in the use of cables for feeds.

2.3.3.4. Auroral Propagation

New charts of auroral absorption are being prepared.

2.3.3.5. H.F. Propagation in Equatorial Regions (including flutter fading)

H.F. transmissions have commenced from Monrovia with reception points at Natal (S.America), Tomale and Zaria which lie along the magnetic equator; Accra is a control circuit in an approximately trans-equatorial direction. It is planned to study both amplitude and phase variations of the signal, hoping that this will throw light on the mechanism of flutter fading. Saw-tooth modulation may also be used for diagnostic purposes. To aid the separation of the factors affecting flutter fading, two transmissions on harmonically related frequencies will be used (10·1018 and 20·2036 Mc/s). It is not possible at present to say whether this work will lead anywhere. No corresponding m.f. measurements are contemplated at the moment.

2.3.3.6. Study of Proposed Medium-Frequency High-Power Station in Africa

NBS have made a theoretical study of the VOA proposal to site a m.f. transmitting station of between 1 and 10 MW to serve Africa.[8] Two sites, one on Ascension Island and the other in Liberia were considered, and coverage maps drawn based on both the Cairo 1937 and CCIR 1962 propagation curves. NBS do not appear to have studied the difficulties associated with propagation in the tropics for:

(i) E-W propagation at the magnetic equator

(ii) N-S two-hop propagation over the sea

nor have they at present any plans to do so; they agreed, however, that both effects may be important, and wish to be kept informed of the United Kingdom activities in this field.

A factor which may be of some importance to the BBC emerged from this NBS study. Non-linearity effects with the high powers involved may be equivalent to a reduction in the effective power of the transmissions.[8] In one theoretical study cited, at a range of 400 km 5 MW was equivalent to a power of only 3 MW on account of interaction effects. This effect is stated to become weaker with increasing distances; indeed, for modest field strengths one would not expect the interaction effect to be important. Nevertheless, we consider that this matter should be investigated in connexion with the proposed BBC high-power stations in Sarawak and Ascension Island.

2.3.3.7. Non-linear Effects

The trend to higher transmitter powers has aroused fresh interest in possible non-linear effects (see Section 2.3.3.6). It was agreed to allocate VOA funds to support the calling of a Conference on this subject, to be held in the United States, during 1963.

2.3.3.8. Satellites

Relay is scheduled to be launched on December 10th/11th and Syncom in mid-January.

A new system is under consideration by the Defence Department, whereby the satellites operate only when in sunlight, i.e. with no storage facilities; the ground stations will probably be similar to, but improved versions of, existing ones.

2.4. Antenna Studies

2.4.1. General-purpose Wideband Array

Lengthy discussions took place concerning the possibility of developing a new type of array for h.f. broadcasting; this would form another 'building block' to add to the curtain and the rhombic for meeting new requirements. As a result of earlier discussions, a specification was prepared in May 1962, detailing the performance required of an idealized array to meet VOA requirements.[9] The performance specification corresponded broadly with that of an HR4/4/1 array, but with the following additional facilities:

(i) horizontal slew over a range of ±60°
(ii) vertical slew to give elevation angles of 8° - 22°
(iii) frequency range 5·8 - 27 Mc/s
(iv) multiplexing of two transmissions, each of 1000 kW

Eleven firms submitted proposals in response to this enquiry, but three were considered technically inadequate. Those remaining were considered by the Antenna Group and rated according to certain criteria, the 'points' being added to give the final rating.[10] This stage had been reached when the position was explained to the main Conference. A summary of the technical proposals has been distributed since the Conference ended.[11] Unfortunately, this was not available at the time of the discussions and came out piecemeal during the meetings. This made it difficult for those unfamiliar with the proposals to make constructive proposals.

No firm attempted to give a fully-engineered design, but indicated instead the form recommended for detailed study. The proposals may be classified as follows:

(i) Parabolic torus reflector with moveable feed aerial. This would require a 650 ft tower, supporting a screen about 1800 ft wide, 650 ft high, and 960 ft deep. The feed aerial would move along the ground parallel to the torus at one half the torus radius.

(ii) A pair of parabolic reflectors (to cover the required azimuthal range), with a moveable feed mounted 200 ft above ground level.

(iii) A cluster of eight tapered horns, arranged in a semi-circle. Four would cover the lower octave (each having a feed section 160 ft × 160 ft × 80 ft, the horn being 500 ft long) and four of half the size for the higher octave.

(iv) An array of wire-grid Luneberg lenses, with associated horn radiators; the overall dimensions would be 500 ft high, 625 ft wide and 600 ft long.

(v) A cluster of log-periodic arrays.

(vi) A combination of three-band curtain arrays.

In the discussion that followed, some confusion appeared to reign as to the guiding principles on which the choice should be made. At the outset the Chairman of the Antenna Group, Dr. Brueckmann, supported the idea of a phased array (a cluster of independently-fed units) even though the proposal nearest to this was low in the 'points' ranking list. Others pointed out that diplexing for 1000 kW power was quite different from diplexing for 250 kW, and that diplexing might prove to be the major difficulty of the concept as a whole. Criticisms were also made of the rating system, in which factors appeared to have been arbitrarily weighted equally. The application of any of these ideas to the Malta site, where the area is very limited, caused further confusion. Eventually the minimum site area requirement was decided to be the important one, but as we had no drawings showing this feature of the various proposals, it was not easy to decide which was better from this point of view.

To cut a long story short, despite two evening meetings lasting until midnight, no decision was reached. We had the impression that the position had not been fully thought out, that technical novelty had been assumed to imply progress, and that the mechanical complexity of some of the systems considered was underestimated. We also thought that some of the 'very wideband' arrays were in fact comparable in complexity with a number of simple curtains giving the same performance; furthermore, it appeared that the multiplexing proposal might introduce more problems than it solved. Mr.J.Ross, Chief of the VOA Technical Division, was well aware of these difficulties, but had not apparently been able to carry the Antenna Group with him. At the final meeting at which a 'definite decision' was to be made, some members expressed reservations regarding the complicated proposals, and as a result, the whole question was deferred for further consideration by the Antenna Group. At this strategic point in the discussion, Mr.J.Ross managed to get agreement to sponsor a design study of the most modest of the proposals - the triple-band, wide slew, variable elevation angle curtain array - and this was agreed.

The relative performance of horizontally- and vertically-polarized arrays was also briefly discussed. The Antenna Group thought there was nothing to choose between them, but we pointed out that theoretically appreciable losses (3 dB or more) occur in launching vertically-polarized waves; furthermore, early BBC experiments, although far from conclusive, tended to confirm this view. It was agreed to try to resolve our points of view by correspondence.

2.4.2. Calculated and Measured Radiation Patterns of Rhombic Aerials

NBS have set up a programme for computing the radiation pattern of a rhombic aerial. The conventional theoretical expression is used, but ground loss is taken into account. Good agreement[12] has been obtained with measurements made on Signal Corps rhombics.

2.5. Modulation Techniques

Dr. P.C. Goldmark of CBS is making a study of modulation techniques on behalf of VOA. The most recent progress report is available.[13]

2.5.1. Clipping and Pre-emphasis Tests

A number of tape recordings were played of speech items (without an interference background) to show the effect of the following variations at the transmitter in the U.S.A.

(a) 9 dB clipping with pre-emphasis (as Langevin clippers).

(b) 0 dB clipping but with pre-emphasis.

(c) No clipping and no pre-emphasis.

Recordings were made at Tangier and at Thessaloniki. The former showed the effect of single clipping and single pre-emphasis, and the latter the effect of double clipping and double pre-emphasis.

In the absence of interference or jamming, the clipped output sounded unpleasant, muffled and 'muddy'. The pre-emphasised output without clipping was clearest, but the modulation level sounded low although we were told that in all instances great care was taken to modulate the transmitter to 95% on negative peaks. It seemed probable that the modulation level was being determined by the pre-emphasised high frequencies, resulting in the more audible low frequency vowel sounds being transmitted at low level. This effect was particularly noticeable on the double pre-emphasised output.

Single pre-emphasis was said to be +10dB at 4800 c/s together with a bass cut of 8dB at 50 c/s.

There was some discussion of special frequency correcting networks for individual announcers. VOA said they had tried this some years ago with no conclusive results, but they would be interested to hear the BBC findings from their work in this direction. CBS also have work in hand on this subject.

The tape recordings did not seem to prove very much, and there was little discussion. We were asked for the BBC views and practice concerning peak clippers, and we gave the results of tests conducted ten years ago which showed a 3½dB advantage in favour of clippers in the presence of 'white' noise, and a further 1dB advantage if a compressor was used between the frequency shaping stage and the clipping stage. VOA seemed very interested in these results which appeared to be new to them. We said the BBC present practice was to use clippers only on speech programmes which were subject to jamming.

In passing it may be mentioned that in Reference 13 it is stated that the Hungarians prefer to listen to BBC broadcasts, in preference to VOA, because they find them 'most objective'.

2.5.2. Reduced Bandwidth Systems

CBS are exploring ways of reducing the bandwidth of speech signals for feed purposes. The aim is not merely to save bandwidth, but also to

increase reliability and to avoid distortion and jamming, without destroying the intelligibility or naturalness of speech.

A tape recording was played of a Melpar Vocoder operating with a 20 to 1 bandwidth compression (bandwidth 120 c/s) under jamming conditions. We thought the results were very poor and of no interest for broadcasting. An improved vocoder is being developed by Gabor-Vectron in England. Robin of D.W.S. is concerned with this development, and it is proposed to split the total cost of $64,000 for 3 sets of equipment 1/3 to D.W.S., 1/3 to VOA and 1/3 to NRDC. The system will use a disc or drum for storage and will have a variable bandwidth compression of up to 10 to 1. Robin said they were working on the specification which included a clause stating that a particular voice must be recognisable by six members of the committee concerned. Vowel sounds may possibly be added at the transmitter. The system will send only one voice at a time.

2.5.3. Kahn Symmetra-Peak Device

This was reported by VOA to give approximate symmetry of the waveform, but only at the expense of increasing the overall peak-to-peak range. They are not convinced of the usefulness of the device.

2.5.4. Kahn Echoplexer

Kahn has proposed this device for VOA feed circuits. The speech spectrum is divided into six blocks, and alternate blocks grouped. One block is then delayed by about one second and recombined with the other. It is then 'decoded' at the receiving end. Kahn claims it is equivalent to improving the mean to peak ratio by about 6 dB, and that selective feeding will be less important than in normal circuits.

We felt that the claims sounded rather doubtful, and the decoding process difficult. VOA decided, however, to finance Kahn to the extent of giving a laboratory demonstration of his idea (see Section 2.6.).

2.5.5. Point-to-Point Feeds

Robin said he has an application in to the British Post Office for permission to establish point-to-point circuits to feed relay stations. This would relieve the load on the broadcasting channels which were at present used to feed these relay stations. It was agreed desirable that all users of relay stations should get together and make a combined approach for these links.

2.6. Proposed VOA Research Programme

Mr. Loomis said that there was in this financial year an unallocated sum of $600K; this was after allowing for existing projects. There was an additional sum of $500K available for the next financial year.

The following tentative allocations were suggested:-

	$K
Investigation of non-linear effects (see Section 2.3.3.7.)	10
Kahn Echoplexer (see Section 2.5.4.)	23
Computer time for propagation studies	50
Backscatter studies (see Section 2.3.1.)	20
Vectron proposal (one third of total cost - see Section 2.5.2.)	25
Specialised test equipment for monitors (NBS and SRL to produce list)	25
Estimated additional for NBS investigations	120
Estimated additional for SRL investigations	200
	473

This left $627K for special antenna studies and a suggested programme was as follows:-

		$K
(i)	Design study by Melpar, Deco and Emertron to determine best aerial system for very restricted site on Malta. System study on site first to check interference, site availability etc.	100
(ii)	A theoretical study of multiplexing two high-power transmissions on different bands, covering mutual interference, generation of inter-modulation terms and their suppression.	150
(iii)	Low-angle propagation and antennas (CRPL and SRL)	150
(iv)	Development of Emertron triple-band array, with vertical steerability and multiplexing facilities.	150
(v)	Design studies on feeds for wideband arrays, and novel ways of constructing large reflecting curtains	allocations to be decided later

2.7. VOA Science Advisory Group

The names and addresses of the 21 members of the VOA Science Advisory Group are given in Reference 15.

When asked (in private conversation) what, in his opinion, were the benefits to VOA of the work of the Group which had now been in existence for 2½ years, Mr. Henry Loomis gave the following reply:-

(i) The knowledge that their performance was not lacking due to failure to investigate the problem and seek advice.

(ii) The development of backscatter techniques which enabled measurements to be made on service transmissions.

(iii) The development of computer techniques to determine the optimum frequencies when preparing schedules.

(iv) Improved knowledge of propagation conditions in equatorial latitudes.

(v) Work which shows promise of improvements in point-to-point performance for sending programmes to relay stations.

3. MISCELLANEOUS TOPICS

3.1. Vestigial Sideband Shaping

In view of the present re-thinking by the BBC relating to vestigial sideband shaping we made enquiries with both the FCC and RCA concerning American practice and experience. Before dealing with the results it is worth mentioning that the present BBC practice in Band I dates from the design of the Sutton Coldfield station - the first single sideband installation in the United Kingdom. This specification was framed to give what was regarded as a reasonable cut-off of the sideband (a 10 dB cut in 0·5 Mc/s) without either undue technical difficulty or group-delay distortion; the same specification has been used for all subsequent BBC Band I stations. Later the CCIR adopted a standard involving a 20 dB cut in 0·5 Mc/s. It was decided to meet the CCIR requirement for the Crystal Palace u.h.f. installation, and in doing so significant group-delay distortion was experienced; a large part of this distortion was associated with the vestigial sideband filter. This raises the question as to whether this degree of sideband shaping is necessary, and if so what degree of distortion can be accepted on this account.

We ascertained first that the FCC do in fact specify the CCIR characteristic and that the requirement is met by the broadcasters. We were told that this characteristic was considered necessary for protection of other services (but of course this applies only at one end of each band) and also to prevent mutual interference between adjacent-channel stations. There appears, however, to have been no controlled tests to decide whether this degree of shaping is really necessary; indeed, several cases were mentioned by the FCC where vestigial sideband filters had been removed at certain stations for short periods, without any harmful effects. Nevertheless, the FCC seemed reluctant to consider a change, but more on the basis, we felt, of 'letting sleeping dogs lie'.

In discussing the harmful effects of too severe sideband shaping on picture definition we continually found ourselves up against the difficulty of having no absolute reference for comparison purposes - such as the K-rating used in the United Kingdom. An internationally agreed signal for testing the whole chain, including the camera, seems to us very desirable. Lacking this, we formed the impression that our standards of definition may well be somewhat higher than those of the United States; we found deficiencies were not infrequently justified by saying they were less than others in the system, without it being clear whether these 'other' deficiencies were fundamental or not.

At RCA we discussed the problem with Mr. Gihring, the Antenna Division Manager. He said that he thought the shaping characteristic was determined by the calculated 'spread' of the synchronizing pulses, in association with propagation information. He also said he thought one experiment had been carried out by RCA between adjacent-channel stations operating in Washington and New York, removal of the filter causing visible interference. Mr. Gihring agreed this was somewhat nebulous, but as he was not very familiar with the subject he would have preferred us to discuss the matter with another department of RCA. Unfortunately our tight time schedule prevented this.

The view of RCA's Mr. C. Storner, Manager - High Power Transmitters, was that they had to sell transmitters which conformed to existing regulations. They even provided high power VSB filters when supplying high power amplifiers for adding to existing stations which were already radiating on low power with the correct VSB characteristic. He said they did this because non-linearity in the amplifiers might re-generate the suppressed sideband. When pressed for details of measurements made to check this effect they did not seem to have made any, and said that amplifier plus filter was the recognised arrangement.

RCA provide video delay correctors to compensate for the group delay distortion due to the VSB filter. These are adjusted to give the best result on the output of the monitoring receiver. At WBAL Mr. Wilner said they had carefully aligned a receiver and had used this to adjust the transmitter video delay correction. He appreciated that this method meant that the correction was only accurate for that receiver but said they had not had time to investigate the problem further. He did not think the remaining distortion was serious. Whether the CCIR specification for Bands I and III is right or wrong, the same does not necessarily apply to Bands IV/V. An appraisal of the whole situation, as planned at the recent EBU London meeting, therefore seems to us entirely justified.

3.2. U.H.F. Television

3.2.1. Transmitters

RCA told us they would not make future UHF transmitters similar to the one in the Empire State Building. They had a less expensive tetrode they would use for 25kW output. Their standard sizes were 1kW, 12·5kW and 25kW, and they had nothing to offer between 1kW and 12·5kW. They were

looking into the use of klystrons instead of tetrodes, but were concerned about X-rays from klystrons operating at 17kV beam voltage; furthermore, they were not sure that the phase characteristics would be suitable for colour. They were very interested when we told them our old-model klystron was proving satisfactory for colour.

The RCA engineers would not quote prices for their UHF transmitters.

The RCA transmitter catalogue Reference 16 gives some details of their UHF transmitters.

3.2.2. Transmitting Aerials

3.2.2.1. RCA Aerials

The present RCA practice is based on the slotted cylinder first developed some ten years ago; a copy of their latest catalogue is available.[17] Some aerials have only a nominal null fill-in (maximum to minimum field-strength ratio between 3:1 and 5:1), with a gain of 1·0 per wavelength; others have shaped patterns, using an offset rather than a central feed, with good fill-in. However, this entails a loss of about 1 dB in gain and costs the customer very much more.

Present RCA candelabra designs involve only *one* u.h.f. aerial, and one or more v.h.f. aerials. Since the latter have a relatively large projected area, the spacings between candles must be at least 100 ft in order to reduce h.r.p. serrations to ±2 dB (the associated short-delay ghost signals were not regarded as important by RCA compared with other degradations of the quality). The insertion loss between these aerials, measured at the base of the feeding lines, is about 30 dB, which is considered acceptable by RCA.

If u.h.f. candles had to be catered for, RCA say they would use spacings maybe as small as 20 ft, or alternatively such as to give serrations not more than ±2 dB in the h.r.p.

3.2.2.2. RCA Filterplexers

The networks for combining sound and vision and for vestigial sideband shaping are included in the filterplexer.[18] This is similar in principle to that previously described by Page,[19] but the cavities are now of silver-plated invar; the two like cavities tend to 'track' together as the temperature changes, but a bi-metal operated compensator is also used on the resonators to correct for ambient temperature changes, and also to avoid warm-up drift. Filterplexers having power ratings of up to 25 kW are available.

3.2.2.3. RCA Transmission Lines

RCA use coaxial lines of up to $9\frac{3}{16}$ in. diameter for u.h.f. installations;[20] these are made up of lengths of about 20 ft, in which the inner conductor is supported by Teflon discs. For certain channels 19½ ft lengths are used to prevent cut-off characteristics.

An impedance of 75 ohms is used, rather than 50 ohms, to increase the cut-off frequency of unwanted modes. For instance, $9\frac{3}{16}$ in diameter line is good up to 632 Mc/s and $6\frac{1}{8}$ in up to 890 Mc/s. The power rating of the $9\frac{3}{16}$ in line is about 120 kW r.m.s. at 700 Mc/s, and of the $6\frac{1}{8}$ in line 50 kW at 960 Mc/s. These could, if necessary, be multiplied by about 1·2 by increasing the working pressure to about 2 atmospheres.

A problem of concern to the RCA is the form of the aerial impedance specification. In the past the s.w.r. was specified to be not worse than 1·1 at the base of the feeder, or, following BBC practice, a better match at the carrier and a worse match at the extreme sideband frequency. With the increasing line lengths now commonly used it had become difficult, and indeed unnecessary, to meet this requirement. RCA therefore specify the performance in terms of a pulse test. The level of individual delayed signals at the base of the feeder are allowed to be:

V.H.F. 3% due to aerial, 1% for any shorter time delays

U.H.F. 4% due to aerial, 1½% for any shorter time delays

We consider this approach very sensible, and that a similar form of specification should be adopted by the BBC.

Waveguide is little used, as yet, mainly because it has not been so heavily financed as cable development, but it seems likely to come in for higher powers in the future. RCA have considered waveguide made by Dielectric Corporation, which has a s.w.r. not exceeding 1·01 per 10 ft section. As with cable, a different standard length may be necessary for certain channels, to avoid cut-off tendencies.

3.2.2.4. Skew Aerial used at Station WNYC, New York

This aerial was designed by Melpar, under contract with the FCC, for station WNYC, Channel 31, New York.[21] It had to be mounted on the square section of the Empire State Building tower, and to be interleaved with the Channel 2 array on the same section. It was necessary to evaluate not only the performance of the Channel 31 array, but also the effect of the Channel 31 array on the Channel 2 service.

The arrangement eventually adopted was a skew system comprising four elements at the corners of the square section. The elements are spaced 11·5 ft (6·75λ) apart at the corners of a square, and are driven in progressive phase; the height of the aerial is 32 ft and the gain is 17·5 dB. Each element is an end-fed slotted waveguide, with wings to shape the radiation pattern; there is a probe at the base for launching the wave into the guide. The amplitude of the radiation from individual slots is controlled by means of probes at one side of each slot, the insertion of the probe being controllable. No phase adjustment is provided, since correct phasing is 'built-into' the design, by choosing the size of the guide. The h.r.p. of the final arrangement is claimed to be uniform to within ±4 dB, while the effect on the Channel 2 aerial is negligible. Good gapfilling was achieved and demonstrated to the FCC.

Although the performance of the aerial seemed adequate for the purpose in mind it has little interest as far as the BBC is concerned, on account of the narrow bandwidth. For instance, the beam tilt for the vision carrier was 2½°; at the sound carrier, however, the beam tilt had changed to 1½°.

We raised the question of the nulls (incident at about 3000 ft distance in this case) inherent in an arrangement of this sort. We were told that, although this had not been specially investigated, the FCC were quite sure that the field is so distorted by reflexions from high buildings as to completely mask this effect.

3.2.3. Receivers

There is no general standard of performance prescribed by the FCC for u.h.f. receivers. By April 1964, however, all sets will have to be capable of receiving u.h.f., and to have a noise factor better than 18 dB. Image channel selectivity is not included in the regulation.* There is, however, a specification agreed by the Trade, and Mr. D.A.V. Williams has been asked to obtain the relevant documents from Electronics Industries Association, 1725 De Sales Street, New York. The additional cost of adding u.h.f. was estimated to be between $20 and $30. It was said to be unlikely that transistors would be used in u.h.f. receiver 'front-ends' within the next two years. Tunnel diodes had been used for experimental u.h.f. oscillators, but results were inconsistent in production.

We enquired about the de-intermixture** proposal. There has been some voluntary action along these lines. In other cases the FCC has withdrawn their proposals on account of objections in Congress. De-intermixture may never come in.

3.2.4. Propagation

The latest FCC report on the WNYC New York UHF Trials[22] has already been received in the BBC. This deals with only 800 locations, restricted to 25 miles from the transmitting station (the majority were within 10 miles). There will be two further reports issued, probably in February, 1963. One will analyse receiving conditions at 4000 locations (where the receiver was taken in, observed and then removed) but again within 25 miles radius, and the other will cover a field strength survey out to a greater range.

One important point made in the report is that although propagation difficulties affected the ability to get a good picture on u.h.f. compared with v.h.f., the additional difficulties of getting a good colour picture on u.h.f. were no greater than on v.h.f.

3.3. Colour Television

We took the opportunity to make general enquiries about the present position on colour, and in particular to gather information on what reception was like in the home.

*In the WNYC tests the image rejection ratio was specified to be not less than 35 dB (the British standard is 55 dB).

**i.e. separating areas into v.h.f. only or u.h.f. only.

3.3.1. Comments on the Present Position

We enquired why colour television appeared to have been extremely slow in growth in the United States. Almost invariably the first reason given was the cost - $500 was clearly a lot of money to the people to whom we spoke. Quite often subsidiary reasons were advanced later, but the cost was the instinctive reason first given.

On the other hand, many people expect receiver sales to start climbing rapidly in the near future. Whether this opinion stems from good advertising, or whether people are conscious of improving reception conditions is not very clear. However, the fact that almost all manufacturers are producing (or are planning to produce) colour receivers in the near future (as recently reported by H.E.S.G.) suggests that colour is 'over the hump'. The RCA Loomington plant is now producing colour receivers on a 24-hour basis, and were making 800 sets per day last August. They are pleased that other manufacturers are also in production, as they sell them many colour components and collect royalties. We were told that about 2% of the television receivers now sold are colour sets. The cheapest set is about $500, but virtually no one buys at list price in the United States, and an old set worth only about $20 can be 'traded-in' at about $100. In the shops the colour sets listed at $580 are about 2¼ times the price of similar size and style black and white sets. Transportable black and white sets in plastic cases are listed at $169 and the cheapest colour set in an unattractive case on legs is $495. A catalogue of current RCA receivers (monochrome and colour) is available;[23] the sets are not priced. There is still some difficulty to be overcome with the RCA 90° colour tube, so that the associated sets are not yet in production. The colour tube now sells at about $75. Last year the RCA receiver division made a profit for the first time, and ten years is expected to see the RCA investment in colour back.

3.3.2. Colour in the home

We spoke to two engineers who owned colour receivers. One was Mr. Casian, Manager of RCA Licensee Services, and 18 months ago he had been given a set by the Company to appraise its reliability and stability. He said the set worked correctly immediately it was switched on and it was not realigned on arrival at his home. It takes 5 minutes to warm up and attain correct colour registration. The controls were not touched by anyone for the first 3 months and no major work had been necessary during the 18 months he had had the set. Variations which might cause people to adjust their sets were usually due to the transmission, and were corrected in due course at the sending end. There were very n ticeable differences between colour cameras. He also blamed much of the poor quality colour on the use of video tape, but said that results were improving. The major improvement in colour receivers occurred about 3 years ago with the introduction of the new high contrast colour tube. Although he also owns a black and white receiver, his family normally look at monochrome on the colour set.

The other engineer who used a colour receiver was Mr. H. Kassins of FCC in Washington. He said the set was trouble-free. He said colour tape gave poor results, due to banding noise and poor definition, and also on a long

studio show the colour camera drift was very noticeable after 1½ hours. In his opinion viewers adjusted their sets to pastel shades to avoid the more annoying defects, but other people we spoke to said viewers had their pictures too saturated. Outside broadcasts were not too successful in colour as the cameras seemed unable to deal with the wide variation in light values and detail was lost when action moved into shadow, e.g. a football passed into the shadow of the stands. On monochrome sets, the definition from colour cameras was noticeably poor. Monochrome on colour sets was poor.

During the visit we saw a number of colour receivers operating on monochrome and thought the results were poor in respect of definition and colour purity, even when allowance was made for the generally poor quality of the received pictures on all sets. There was a colour receiver in the motel lounge at Greenville; this too had been reliable over 1½ years. The pictures suffered from severe ghosting and very bad colour registration, but the owner was not complaining and regularly viewed the programme.

We gathered the impression from general enquiries that it was very easy to adjust the hue control on flesh tones, and that the operation and adjustment of a colour receiver was no more difficult to the average viewer than that of a monochrome receiver. We also enquired whether, in switching from one colour transmission to another, it was necessary to re-adjust the set for correct colour balance. Of the two people who were able to reply to this question (one RCA and one other) the reply was that this was generally unnecessary; however, as mentioned above, differences between individual cameras *could* cause quite a serious difference in colour rendering, but one just had to accept this at present as a problem which would be 'licked' in the future.

In reference 22 it is stated that a colour picture subject to degradation due to propagation effects was rated subjectively lower than a monochrome picture suffering the same degree of degradation. On the other hand, there is little difference between reception of colour on u.h.f. compared with v.h.f.

3.3.3. Video-tape Recording - Visit to NBC Studios, New York

We visited NBC Studios, New York during a normal evening shift. Mr. Whitney Baston showed us round the video tape facilities.

There seemed to have been little change since the 1960 visit of Messrs. Bolt and Phillips which is covered in their report, except that there are now 22 tape machines used in 11 pairs. All recordings and replays are duplicated. About half the machines are RCA, the remainder Ampex and there seemed no preference for either.

We saw on the monitors part of a live studio show in colour and this was followed by a tape recording of a colour show. Neither of these was good colour, but even so it was obvious the public would prefer to watch the colour version rather than the black and white rendering of the same material which was on an adjacent monitor. Both shows were of the 'singing and dancing' type with gaily coloured costumes and scenery. The colour registration was very poor, the flesh tones were reasonable, perhaps a little rosy; the general

definition was very poor on both the colour and the monochrome monitors. The definition on the studio show was so poor that the tape recording did not look worse in this respect. The noise on the taped show was perceptible but not worse than the studio show. There was no colour banding nor streaking due to the recording heads except when colour bars were being reproduced, but on these the banding was marked. The 'bars' were said to be 100% saturated 75% amplitude.

We gained the impression that viewers had become accustomed to poor pictures as we understood they were satisfied with them.

Over 70% of NBC shows are now in colour, and of these over 90% are transmitted from tape.

The tape machine operators do no maintenance other than setting-up the machines. There are two and sometimes four maintenance engineers on each shift looking after the whole of the tape installation. Staffing is on a 24-hour basis. Normal duty is 40 hours per week and overtime is paid at time-and-one-half. Picture monitors each require on average about half an hour maintenance per week.

The time allowed for line-up of the studio colour cameras is one hour and the same time is allowed for the colour recorders.

A considerable time is spent on acceptance tests of new tape. A colour bar signal is recorded on it and the tape is sent back under guarantee if it shows defects on play-back.

3.3.4. Four-Tube Colour Camera

We made some enquiries about the progress being made by RCA on the four-tube colour camera comprising one 4½ in image orthicon and three vidicons for the colour difference signals. We learned from Mr.W.R.Casian, Manager, Licensee Services, that this project is running into fundamental difficulties on account of movement blur, and that though it is expected that this problem will eventually be solved there is little likelihood of seeing such a camera in production before the end of 1964.

We therefore thought it would not be profitable, in view of the other work we wished to cover on the day of our visit to RCA, to discuss this work direct with the engineers concerned.

3.3.5. Performance of CBS Transmitter, New York

This station is on the 83rd floor of the Empire State Building and uses a G.E. 35 kW 55 Mc/s transmitter.

In the vision transmitter modulation takes place at low level, and there are three linear amplifiers following the modulated stage. We asked about colour performance and were shown routine test figures and photographs. The results were remarkably good for such a transmitter, the differential phase being nominally within ± 3° but actually within ± 1°, and the differential gain constant within ½ dB.

Maximum depth of modulation is 12½% on 75% amplitude 100% saturated colour bars. These are used for test and of course the white level is about 2 dB down on normal level. On transmission, white is at normal level and highly saturated colours like the yellow on the Kodak advertisements were said to cause buzz, even on a receiver which did not have intercarrier sound.

C.B.S. do no regular colour transmissions. The station is run by an E.i.C. and 6 engineers; there is a period of 3 hours during the night for maintenance.

3.4. Ampliphase Transmitters

The RCA ampliphase transmitters differ from those originally made by Marconi's in having modulated drive applied to the output valves to assist in reducing the output to zero at 100% modulated negative peaks. Without this, Marconi's had difficulty in producing performance figures, as this meant achieving, at all modulating frequencies, good amplitude balance between the opposed vectors. This modulated drive also assists with the positive peaks by ensuring that the valves have adequate drive at all parts of the modulation cycle. RCA claim that the valves have an easier time with ampliphase than with Class B anode modulation, as the anode voltage swing is almost constant and has a peak value considerably lower than the peak value reached with anode modulation.

3.4.1. High-Power Medium-Frequency Transmitters

We were told 50 kW was the highest power m.f. transmitter so far made by RCA. Their literature, however, lists powers up to 250 kW.

3.4.2. 50 kW Medium-Frequency Transmitters

We were shown in the laboratory one of the latest model 50 kW m.f. Ampliphase transmitters and were impressed by its simplicity and small size. Very special precautions had been taken on this transmitter to suppress r.f. harmonics to below -80 dB. Silicon rectifier elements, immersed in oil in small, finned tanks, were used for the 15kV anode supply. No special precautions were taken to protect the rectifier against overloads: the primary contactor disconnected the supply within 3 cycles, and no trouble was experienced in spite of the rectifier output being frequently short-circuited by the gravity-operated earthing device; this functioned before the microswitch at the other end of the transmitter cabinet door broke the interlock circuit. We noted the burn marks on the earthing device. The rectifiers were operated at half the maker's voltage rating, and paralleled elements were not used. Each element had a parallel R and C across it to distribute the inverse and transient voltages evenly.

The performance of the transmitter was said to be very good, only 5 dB of overall negative feedback being necessary to achieve 2% distortion at modulating frequencies up to 7500 c/s. The mains-to-aerial efficiency was about 55% and varied very little between zero and 100% modulation.

3.4.3. 10 kW Medium-Frequency Transmitters

RCA have produced a competitive design of 10 kW ampliphase transmitter which they hope to sell internationally at around $16,000. It is very small in size, measuring about 3'6" wide, 3'0" deep and 7'0" high, and has been made as simple as possible throughout. We saw one of these in their laboratory.

3.4.4. 100 kW High-Frequency Transmitters

The eighth 100 kW h.f. ampliphase transmitter made by RCA had left the works the previous week. None was yet in service, due it was said to delays with the buildings.

At an anode voltage of 12·5kV the overall efficiency was 53% and the distortion under 3%. The incidental phase modulation had been checked to be less than 2°. The transmitter would operate at normal power output into a feeder of nominal impedance of 300 ohms but with a s.w.r. of 1·5 to 1. Two men could wavechange the transmitter from 6 Mc/s to 21 Mc/s within 5 minutes.

A description of the transmitter is given in the August '62 issue of Broadcast News. From this description it does not seem at all attractive, having numerous sliding contacts carrying high r.f. current, many tuning motors, and lead-screws made of insulating material. It will almost certainly be a troublesome transmitter.

3.5. Compatible Single-Sideband Transmission

We were aware of the FCC decision, recently reported by H.E.S.G., not to proceed with the Kahn proposal for compatible single-sideband broadcasting. We were told by the FCC that the major reason for this decision was the increased power in the remaining sideband, with consequently increased interference with an adjacent channel. If complete re-planning of the m.f. spectrum were possible, the FCC thought the system could have important applications. This possibility has certainly not been ruled out, for an overall re-allocation plan. However, the present financial position in the United States makes this impossible. There are too many a.m. operators, many of whom are not making big profits, to make possible a change of system involving substantial costs to the operator. We asked whether the FCC had any comments to make on the Kahn claim that selective distortion was reduced by using CSSB. The taped records made by Kahn tended to support this view, but normal fading was subjectively worse, so that in the FCC view there was no significant overall difference.

3.6. Stereophony

The FCC said that the inception of the Zenith-G.E. stereophony service has not revealed any untoward difficulties. The signal-to-noise degradation is not important in practice because:

(i) the FCC standard for the limit of the service area is 1 mV/m, not 250 μV/m as in the United Kingdom.

(ii) cars are well suppressed, usually by resistive cable in each sparking-plug lead. This practice is voluntary on the part of the Society of Automobile Engineers, and may be due in part to the increasing number of f.m. receivers being used in cars.

About 20% of programme material was said to be going out 'stereo'.

3.7. Zimmite

Mr. J.M. Storey, C.B.E., M.I.MAR.E., was on the 'plane to New York. He is 'Zimmite Consultant' to Houseman I. Thompson Ltd., The Priory, Burnham, Bucks. The telephone number is Burnham 1704; Mr. Storey may also be contacted on Frobisher 1282.

Zimmite is a chemical which, when added to muddy water, will prevent the mud from adhering to condenser tubes, for instance those of power stations on muddy estuaries. It will also prevent the formation of algae by loosening the mud on which the algae grows. This material may prove valuable on our overseas stations if we have to draw cooling water from muddy rivers. It is widely used to clean the ballast tanks of ships, for example coal vessels which draw in Thames water after discharging coal at Battersea; prior to its use it was necessary to dig the mud out of the tanks every six weeks or so.

The concentration necessary is 1 to 2 parts in 10^6, and for water pumps it is sufficient to treat the intake for 10 minutes every 24 hours. A 1% solution of Zimmite costs 8/- per gallon and 350 gallons per year will treat a daily flow of one million gallons of water.

4. RECOMMENDATIONS

We recommend that the BBC should:

(i) take up the SRL proposal in Section 2.3.2. with VOA

(ii) keep in touch with NBS on the matters discussed in Section 2.3.3. and in particular the flutter-fading investigation

(iii) check that non-linear effects do not affect the planning of the Sarawak and Ascension Islands projects

(iv) keep in touch with VOA regarding the proposed general-purpose array (see Section 2.4.1.)

(v) reconsider the present specification for transmitting cables and aerials (see Section 3.2.2.3.)

5. ACKNOWLEDGEMENTS

We wish to record our thanks to the following for the opportunity given to discuss technical problems during our visit.

Voice of America — Mr. H. Loomis, Mr. E. Martin, Mr. G. Jacobs, Mr. J. Ross

Federal Communications Commission	Mr. E. Allen Mr. E.W. Chapin Mr. H. Kassens Mr. A. Skrivseth Mr. S. Lines Mr. J. Dixon
Station WBAL, Baltimore	Mr. J. Wilner
Station WNYC, New York	Mr. D. Rutman
RCA, Camden	Mr. W.R. Casian Mr. Zeramba Mr. H.E. Gihring Mr. C. Storner
NBC, New York	Mr. W. Baston

We would also like to express our appreciation for the arrangements made for the trip by Mr. D.A.V. Williams, of the BBC New York Office.

6. REFERENCES

Copies of the following references are available on request:

1. Agenda, Science Advisory Group, December 3rd-5th, 1962.

2. A Test of the Frequency-Shift-Pulse Backscatter-Sounding Technique in Short Wave Broadcasting, Stanford Electronics Laboratories, October 1962.

3. Proposal for Research on Backscatter Sounding, Stanford Electronics Laboratories, November 1962.

4. Channel Multiplication, Stanford Electronics Laboratories, September 1962.

5. Barrage Broadcast of October 25th, 1962.

6. Semi-annual Report to Voice of America, N.B.S. Report 7621.

7. Long-term Radio Propagation Predictions for VOA Broadcast Cover from Manila, Phillipines, N.B.S. Report 7622.

8. Comparison Study for Proposed VOA Medium Wave Broadcast Station in Africa.

9. VOA Specification No. 283-A: Statement of Requirements for the development of a High-Frequency Antenna.

10. Relative Preference: Companies rated from 1 to 8.

11. An Analysis of Proposals for a Steerable H.F. Antenna in accordance with Specification 283-A.

12. A Comparison of Theoretical and Measured Radiation Patterns for a Signal Corps RD-4 Type Rhombic Antenna.

13. Bi-Monthly Letter Report for October, 1962, Contract IA-8590.

14. A Speech Diversity Combiner for VOA Relay Stations, Deco Electronics Proposal.

15. VOA Science Advisory Group.

16. RCA TV Transmitter Catalogue, Third Edition.

17. RCA U.H.F. TV Pylon Antennas, Catalogue B.5650.

18. RCA U.H.F. Filterplexers, Catalogue B.4506.

19. Page, H. 'Vestigial Sideband Filters and Sound-Vision Combining Units for Television Transmitters', UKSM Memo No. 19/53.

20. RCA Transmission Line Equipment.

21. U.H.F. Television Antenna for the Empire State Building: Final Engineering Report, Melpar Inc.

22. Report on Receiver Installations, New York City UHF-TV Project. J. Deitz, FCC.

23. RCA TV Receiver Catalogue.

BRH
ALG

Printed by B.B.C. Research Department, Kingswood Warren, Tadworth, Surrey